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Digital Finance and Corporate ESG Performance: The Mediating Role of Financing Constraints and Green Innovation-Evidence from Thai Listed Companies

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ABSTRACT. This study examines the impact of digital finance on corporate Environmental, Social, and Governance (ESG) performance in Thailand. Drawing upon stakeholder theory, agency theory, signaling theory, and the resource-based view, we propose a conceptual framework that integrates financing constraints and green innovation as mediating mechanisms. Using panel data from 523 companies listed on the Stock Exchange of Thailand (SET) covering the period 2018-2024, yielding 3,320 firm-year observations, we employ multiple regression analysis to test the proposed hypotheses. The research addresses significant gaps in the existing literature by: (1) investigating the digital finance-ESG relationship in the underexplored context of Thai capital market, (2) examining the dual mediating pathways through which digital finance influences sustainability outcomes, and (3) considering the moderating role of family ownership structure. This study contributes to the growing body of knowledge on sustainable finance and provides practical implications for policymakers and corporate managers seeking to leverage digital financial technologies for sustainable development in emerging markets.

1. Introduction

Public companies have increasingly disclosed information on environmental, social, and governance (ESG) issues over the past decade because stakeholders are satisfied when companies consider ESG issues [1]. To ensure ESG data is of high quality and reliable, companies continuously strive to improve their ESG data collection and reporting practices. Environmental, Social, and Governance (ESG) considerations have become increasingly important in financial markets, serving as concrete manifestations of corporate commitment to sustainable development [2]. According to recent surveys, approximately 75% of institutional investors now consider ESG factors important when selecting quality investments, representing a significant increase from

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60% in 2017. Simultaneously, digital finance has emerged as a transformative force in the financial sector, fundamentally changing how financial services are delivered and consumed [3,4]. Digital finance encompasses various technology-driven financial innovations, including mobile payments, online lending platforms, blockchain-based financial services, and fintech applications [5]. These innovations have significantly enhanced financial accessibility, reduced transaction costs, and improved the efficiency of capital allocation [6,7]. The purpose of ESG reporting is to reduce or eliminate information asymmetry between companies and investors, enabling investors to make more informed investment decisions based on both financial reports and non-financial ESG reports [8].

In Thailand, the Stock Exchange of Thailand (SET) has developed and supported ESG-related information disclosure since 2015, encouraging listed companies to report on environmental, social, and governance issues. The Thai stock market, which is reported to be family business-oriented [9], presents a unique context for examining the relationship between digital finance and ESG performance. As of January 2024, 858 companies are listed on the Stock Exchange of Thailand, representing a significant market for studying sustainable finance practices in emerging economies. The certification of ESG reporting by external agencies is intended to increase the credibility and accuracy of the disclosed information, with third-party verification indicating that the report has been independently verified to ensure accuracy [10].
Despite the growing importance of both digital finance and ESG performance, the relationship between these two phenomena remains underexplored, particularly in the context of the Thai capital market. The existing literature has primarily focused on the impact of digital finance on financial performance, economic growth, and traditional measures of firm value [11,12]. However, limited attention has been paid to how digital finance affects corporate sustainability outcomes. Previous studies have shown that senior executives possess more information than investors, and decisions made by top management can have a significant impact on investment decisions made by investors in the future [13-15].

Furthermore, most studies examining the digital finance-ESG nexus have focused on developed economies or China [16,17], leaving a significant gap in our understanding of this relationship in ASEAN countries like Thailand. The informativeness of ESG scores and their credibility and their effects on stock market reactions are still inconclusive and understudied, especially in emerging countries due to insufficient data [18,19]. Thailand, with its dynamic growth trajectory, family-dominated business structure, and evolving digital finance ecosystem, provides an ideal research context for investigating these relationships. The significance of this research lies in its potential to inform both policy and practice in the Thai context. Understanding how digital finance can promote corporate ESG performance is crucial for achieving the United Nations' Sustainable Development Goals (SDGs), particularly in developing economies facing

significant financing gaps for sustainable development. According to the United Nations Conference on Trade and Development (UNCTAD), developing countries face an annual SDG financing gap of USD 2.5 trillion, highlighting the urgent need for innovative financing solutions. A comprehensive review of the existing literature reveals several interconnected research gaps that this study aims to address. While prior research has extensively examined the relationship between digital finance and financial performance [4,20], limited empirical evidence exists regarding its impact on ESG performance, particularly in the Thai capital market, representing a significant oversight given the growing importance of sustainability in corporate strategy and investor decision-making. This geographical limitation is compounded by the fact that the mechanisms through which digital finance influences ESG performance remain poorly understood; although studies have suggested that financing constraints and green innovation may serve as important mediating factors [7,21], comprehensive empirical testing of these mechanisms in the context of Thai listed companies is lacking. Moreover, existing studies have largely ignored the potential moderating role of institutional factors and family ownership structure in the digital finance-ESG relationship, which is particularly problematic given that Thai stock market is dominated by family-run companies [9] and the importance of understanding how this unique context shapes the relationship for developing targeted policy interventions.

Furthermore, the concept of double materiality, which emphasizes the dual perspective of how sustainability issues affect firm value and how firms impact society and the environment [2], has not been adequately integrated into studies of digital finance and sustainability in the Thai context, leaving a theoretical void in understanding the bidirectional nature of the digital finance-ESG nexus. Collectively, these gaps highlight the need for a comprehensive study that examines the digital finance-ESG relationship in Thailand while considering both the mediating mechanisms and the institutional contingencies that shape this relationship.

This study aims to address the identified research gaps by pursuing the following objectives: (1)

To examine the direct relationship between digital finance development and corporate ESG performance in Thai listed companies; (2) To investigate the mediating role of financing constraints in the digital finance-ESG relationship; (3) To explore the mediating role of green innovation in the digital finance-ESG relationship; (4) To analyze the moderating effect of family ownership on these relationships; and (5) To provide theoretical contributions and practical implications for policymakers, corporate managers, and investors in Thailand.

2. Literature Review

2.1 Digital Finance: Conceptualization and Development

Digital finance refers to the application of digital technologies to financial services, encompassing a broad range of innovations including mobile banking, digital payments, online

lending, blockchain-based financial services, and artificial intelligence-driven financial analytics [4]. The digitalization of finance has fundamentally transformed the financial sector, enabling more efficient, accessible, and cost-effective delivery of financial services [20,22].

The development of digital finance has been particularly rapid in emerging economies, where traditional financial infrastructure is often underdeveloped. In Thailand, digital financial services have emerged as a key driver of financial inclusion, providing access to financial services for previously unbanked populations [3]. The country's young, digitally savvy population and high smartphone penetration rates have created favorable conditions for digital finance adoption.

Recent research has highlighted the multidimensional nature of digital finance, identifying three key dimensions: breadth of coverage, depth of use, and degree of digitization [16]. The breadth of coverage refers to the geographic and demographic reach of digital financial services. The depth of use captures the intensity and diversity of digital finance utilization. The degree of digitization reflects the technological sophistication and innovation of digital financial services. Understanding these dimensions is crucial for assessing the potential impact of digital finance on corporate sustainability outcomes.

2.2 ESG Performance and Signaling Theory

Environmental, Social, and Governance (ESG) performance has emerged as a critical metric for evaluating corporate sustainability and responsible business practices [23]. Spence's Signaling Theory [13] is based on the asymmetry of information between companies and investors. If a firm is experiencing a good business trend and has new projects that will yield high returns, investors receive a positive message which increases the value of their common shares. Consequently, signaling theory can be used to explain stock market reactions to ESG disclosures, as companies send positive signals to investors by communicating non-financial information through ESG reporting [13-15,24].

The importance of ESG performance has been amplified by the growing recognition that sustainability considerations are material to long-term firm value. Research has demonstrated positive associations between ESG performance and various corporate outcomes, including financial performance, risk management, access to capital, and stakeholder relationships [11]. The certification of ESG reporting by external agencies is intended to increase the credibility and accuracy of disclosed information, with independent certification serving as a bridge between corporate and investor interests [25].

The concept of double materiality has gained prominence in recent years, emphasizing that companies should consider both how sustainability issues affect their financial performance (financial materiality) and how their operations affect society and the environment (impact materiality) [2]. This dual perspective is particularly relevant in the context of the Thai capital market, where firms face unique sustainability challenges and opportunities.

2.3 Digital Finance and ESG Performance: Theoretical Foundations

2.3.1 Stakeholder Theory

Stakeholder theory provides a foundational framework for understanding the relationship between digital finance and ESG performance. According to stakeholder theory, firms should consider the interests of all stakeholders, not just shareholders, in their decision-making processes [23]. This perspective suggests that firms engaging in ESG activities do so because management desires to promote socially responsible practices, regardless of their financial slack situation.

Digital finance can enhance firms' ability to address stakeholder concerns by improving information transparency, facilitating stakeholder engagement, and enabling more efficient resource allocation toward sustainability initiatives. The enhanced information accessibility provided by digital financial platforms allows stakeholders to better monitor corporate ESG practices, creating incentives for firms to improve their sustainability performance.

2.3.2 Agency Theory

Agency theory offers complementary insights into the digital finance-ESG relationship. Traditional agency theory focuses on the conflicts of interest between principals (shareholders) and agents (managers) and the mechanisms to align their interests [26]. In the context of ESG, agency problems can manifest as managers prioritize short-term financial gains over long-term sustainability investments.

Digital finance can help mitigate agency problems by reducing information asymmetry between managers and stakeholders, improving corporate governance through enhanced transparency, and lowering the costs of monitoring and verification [4]. Digital technologies such as blockchain and artificial intelligence enable more accurate and timelier ESG reporting, reducing opportunities for greenwashing and enhancing the credibility of sustainability claims.

2.3.3 Resource-Based View

The resource-based view (RBV) provides additional theoretical grounding for understanding how digital finance influences ESG performance. According to RBV, firms gain competitive advantage through the acquisition and deployment of valuable, rare, inimitable, and non-substitutable resources [27]. Digital finance capabilities can be considered as strategic resources that enable firms to access capital, acquire sustainability-related knowledge, and develop green innovation capabilities.

Furthermore, the dynamic capabilities perspective extends RBV by emphasizing firms' ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments [27]. Digital finance development can enhance firms' dynamic capabilities by providing the financial resources and information infrastructure necessary for adapting to evolving sustainability requirements and stakeholder expectations.

2.4 Mediating Mechanisms

2.4.1 Financing Constraints as a Mediator

Financing constraints represent a critical barrier to corporate sustainability investments, particularly in emerging markets like Thailand where access to capital is often limited [5,17]. Firms facing financing constraints may be unable to invest in ESG initiatives, which often require substantial upfront investments with uncertain and long-term returns.

Digital finance can alleviate financing constraints through multiple channels. First, digital financial platforms reduce information asymmetry between firms and capital providers, enabling more accurate credit assessments and risk pricing [7]. Second, digital finance expands the range of financing options available to firms, including crowdfunding, peer-to-peer lending, and supply chain financing [6]. Third, digital technologies reduce transaction costs and improve the efficiency of capital allocation, making it more economically viable to finance smaller-scale sustainability projects.

2.4.2 Green Innovation as a Mediator

Green innovation, defined as the development and adoption of products, processes, and practices that reduce environmental impact, represents another potential mediating mechanism linking digital finance to ESG performance [7]. Green innovation is essential for achieving environmental sustainability goals and has been associated with improved ESG performance across multiple dimensions.

Digital finance can promote green innovation through several mechanisms. First, by reducing financing constraints, digital finance provides firms with the financial resources necessary for research and development investments in green technologies [7]. Second, digital financial platforms can facilitate the matching of green innovation projects with specialized investors and funding sources, such as green bonds and impact investors. Third, digital technologies enable more efficient knowledge transfer and collaboration, accelerating the diffusion of green innovations across industries and regions.

3. Hypotheses Development

3.1 Digital Finance and ESG Performance

Based on the theoretical frameworks discussed above, we expect digital finance to have a positive direct effect on corporate ESG performance. Digital finance enhances information transparency, reduces transaction costs, improves capital allocation efficiency, and facilitates stakeholder engagement, which can contribute to improved sustainability outcomes [4,11].

Hypothesis 1 (H1): Digital finance development has a significant positive effect on corporate ESG performance in Thai listed companies.

3.2 Mediating Role of Financing Constraints

Financing constraints represent a significant barrier to corporate sustainability investments [5]. Firms facing capital constraints may prioritize short-term financial survival over long-term sustainability investments, leading to suboptimal ESG performance. Digital finance, by expanding access to capital and reducing the cost of financing, can alleviate these constraints and enable greater investment in ESG initiatives.

Hypothesis 2 (H2): Financing constraints mediate the relationship between digital finance and ESG performance, such that digital finance reduces financing constraints, which in turn improves ESG performance.

3.3 Mediating Role of Green Innovation

Green innovation represents a key mechanism through which firms can improve their environmental performance and contribute to sustainable development. Digital finance can promote green innovation by providing financial resources for R&D investments, facilitating access to green financing instruments, and enabling knowledge transfer and collaboration [7].

Hypothesis 3 (H3): Green innovation mediates the relationship between digital finance and ESG performance, such that digital finance promotes green innovation, which in turn improves ESG performance.

3.4 Moderating Role of Family Ownership

Family ownership structure can significantly influence the effectiveness of digital finance in promoting ESG performance. Thai stock market is reported to be family business oriented [9], and family-owned firms may have different incentives and capabilities for ESG investments compared to non-family firms. Family owners may have longer investment horizons and stronger reputational concerns, potentially enhancing the positive effects of digital finance on ESG performance.

Hypothesis 4 (H4): Family ownership moderates the relationship between digital finance and ESG performance in Thai listed companies.

4. Research Methodology

4.1 Data Collection

As of January 5, 2024, 858 companies are listed on the Stock Exchange of Thailand. Due to the fact that in 2015, the Stock Exchange of Thailand developed and supported ESG-related information regarding the disclosure of business information regarding environmental, social, and governance issues, the researcher began collecting data during the period 2018-2024 to obtain sufficient ESG disclosure data for analysis.

A data set of 5,817 firm-year observations was initially derived (858 companies × 7 years, adjusted for listing dates). From this initial sample, 225 companies from the Market for Alternative Investment (MAI) were eliminated due to their different capital structure and stock

price movements from larger companies, and the sustainability reporting of companies within the MAI group is insufficient for analysis (1,575 firm-year observations). Additionally, 58 financial companies were excluded from this study's sample because these companies have capital structures and financial reporting regulations that differ from those of other businesses (406 firm-year observations) [28]. Furthermore, 52 companies belonging to various funds were eliminated as their business operations were not similar to that of general listed companies (364 firm-year observations) [29].

This resulted in a sample group consisting of 523 companies, or 3,472 firm years in total. Subsequently, 152 incomplete or inaccurate data observations were eliminated by the researcher. This resulted in a final sample group of 3,320 firm-year observations being used for testing the research hypotheses, as shown in Table 1.

Table 1: Sample Selection Process

Description	**Firm-Year Observation**
Thai Stock Exchange companies (858 companies)	5,817
Less: MAI companies (225 companies)	(1,575)
Less: Financial companies (58 companies)	(406)
Less: Fund companies (52 companies)	(364)
Subtotal	3,472
Less: Incomplete/inaccurate data	(152)
Final sample for analysis (523 companies)	3,320

Note: Data period covers 2018-2024 (7 years). MAI = Market for Alternative Investment.

4.2 Variable Measurement

This section describes the measurement of all variables used in this study. Table 2 provides a comprehensive summary of variable definitions, measurements, and data sources.

Independent Variable

Digital Finance (DF): Digital finance development is measured using the Digital Finance Index, which captures the breadth of coverage, depth of use, and degree of digitization of digital financial services at the provincial level. This index is constructed based on data from financial institutions and digital payment platforms, following the methodology of prior studies [3,6]. The index ranges from 0 to 1, with higher values indicating greater digital finance development.

Dependent Variable

ESG Performance (ESG): ESG scores are obtained from the Refinitiv database, following prior studies [30-32]. The Refinitiv ESG score is a comprehensive measure that evaluates corporate performance across environmental, social, and governance dimensions. The score

ranges from 0 to 100, with higher scores indicating better ESG performance. Refinitiv assesses over 630 ESG metrics and provides scores for more than 12,000 companies globally, making it one of the most widely used ESG data providers in academic research.

Mediating Variables

Financing Constraints (FC): Financing constraints are measured using the SA Index developed by Hadlock and Pierce [33]. The SA Index is calculated as: $SA = -0.737 \times Size + 0.043 \times Size^2 - 0.040 \times Age$, where Size is the natural logarithm of total assets (inflation-adjusted to 2024 THB) and Age is the number of years the firm has been listed on SET. More negative values indicate higher financing constraints. The SA Index is preferred over other measures such as the KZ Index because it relies on exogenous firm characteristics and avoids endogeneity concerns [5,33].

Green Innovation (GI): Green innovation is measured as the natural logarithm of one plus the number of green patent applications filed by the firm in a given year. Green patents are identified using the World Intellectual Property Organization (WIPO) IPC Green Inventory classification, which covers environmentally sound technologies across seven categories: alternative energy production, transportation, energy conservation, waste management, agriculture/forestry, administrative/regulatory/design aspects, and nuclear power generation [7].

Moderating Variable

Family Ownership (Family Own): Family ownership is measured as a dummy variable that equals 1 if the firm is classified as a family business, and 0 otherwise. Following prior research [9,24], a firm is classified as family-owned if: (1) the founding family or their descendants hold at least 20% of voting rights, or (2) family members serve as chairman, CEO, or hold at least two board seats. This definition captures both ownership and control dimensions of family involvement.

Control Variables

Following prior literature on ESG performance determinants [18,19,30], this study includes several control variables to account for firm-specific characteristics that may influence ESG performance:

Leverage (LEV): Measured as total debt divided by total equity. Higher leverage may constrain resources available for ESG investments, suggesting a negative relationship with ESG performance [29].

Firm Size (SIZE): Measured as the natural logarithm of market capitalization in Thai Baht. Larger firms typically have more resources and face greater stakeholder pressure to engage in ESG activities [28].

Firm Age (AGE): Measured as the number of years since the firm was first listed on the Stock Exchange of Thailand.

Cash Flow from Operations (CFO): Measured as operating cash flow divided by total assets. Firms with higher operating cash flows have more internal resources available for ESG investments [25].

Big Four Auditor (BIG4): A dummy variable that equals 1 if the firm is audited by one of the Big Four accounting firms, and 0 otherwise. Big Four auditors are associated with higher audit quality and may promote better ESG disclosure practices [10].

Fixed Effects: Year and industry fixed effects are included to control for time-varying macroeconomic conditions and industry-specific factors.

Table 2: Variable Definitions and Measurements

Variable	Symbol	Measurement	Source
Panel A: Independent Variable			
Digital Finance	DF	Digital Finance Index (0-1)	Bank of Thailand
Panel B: Dependent Variable			
ESG Performance	ESG	Refinitiv ESG Score (0-100)	Refinitiv
Panel C: Mediating Variables			
Financing Constraints	FC	SA Index = $-0.737\times Size + 0.043\times Size^2 - 0.040\times Age$	Calculated
Green Innovation	GI	Ln (1 + Green Patent Applications)	DIP Thailand
Panel D: Moderating Variable			
Family Ownership	FamilyOwn	1 = Family-owned firm, 0 = Otherwise	Annual Reports
Panel E: Control Variables			
Leverage	LEV	Total Debt / Total Equity	SETSMART
Firm Size	SIZE	Ln (Market Capitalization)	SETSMART
Firm Age	AGE	Years since IPO on SET	SETSMART
Cash Flow	CFO	Operating Cash Flow / Total Assets	SETSMART
Big Four Auditor	BIG4	1 = Big Four Auditor, 0 = Otherwise	Annual Reports
Year/Industry FE	—	Dummy variables for year and industry	SET

Note: DIP = Department of Intellectual Property; SET = Stock Exchange of Thailand; SETSMART = SET Market Analysis and Reporting Tool.

4.3 Analytical Approach

The proposed analytical approach includes: (1) Descriptive statistics to summarize the preliminary data of the sample, consisting of mean, standard deviation, maximum value, and

minimum value; (2) Correlation analysis of the sample group using Pearson's correlation coefficients before analyzing the relationship between various variables; (3) Multiple regression analysis to test the hypotheses using the following equations:

Model 1: Direct Effect of Digital Finance on ESG Performance (H1)

$ESG_{i,t} = \beta_0 + \beta_1 DF_{i,t} + \beta_2 LEV_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 AGE_{i,t} + \beta_5 PBV_{i,t} + \beta_6 PE_{i,t} + \beta_7 BTM_{i,t} + \beta_8 Freefloat_{i,t} + \beta_9 CFO_{i,t} + \beta_{10} BIG4_{i,t} + Year + Industry + \varepsilon_{i,t}$

Model 2: Mediation Effect of Financing Constraints (H2)

Step 1: $FC_{i,t} = \beta_0 + \beta_1 DF_{i,t} + Controls + Year + Industry + \varepsilon_{i,t}$

Step 2: $ESG_{i,t} = \beta_0 + \beta_1 DF_{i,t} + \beta_2 FC_{i,t} + Controls + Year + Industry + \varepsilon_{i,t}$

Model 3: Mediation Effect of Green Innovation (H3)

Step 1: $GI_{i,t} = \beta_0 + \beta_1 DF_{i,t} + Controls + Year + Industry + \varepsilon_{i,t}$

Step 2: $ESG_{i,t} = \beta_0 + \beta_1 DF_{i,t} + \beta_2 GI_{i,t} + Controls + Year + Industry + \varepsilon_{i,t}$

Model 4: Moderation Effect of Family Ownership (H4)

$ESG_{i,t} = \beta_0 + \beta_1 DF_{i,t} + \beta_2 FamilyOwn_{i,t} + \beta_3 (DF \times FamilyOwn)_{i,t} + Controls + Year + Industry + \varepsilon_{i,t}$

Where: DF = Digital Finance; ESG = ESG Performance; FC = Financing Constraints; GI = Green Innovation; FamilyOwn = Family Ownership (dummy: 1 = family-owned, 0 = otherwise); DF×FamilyOwn = Interaction term; Controls = LEV, SIZE, AGE, PBV, PE, BTM, Freefloat, CFO, BIG4.

In addition to the above models, robustness tests will be conducted including: (1) instrumental variable estimation to address potential endogeneity concerns; (2) alternative measurements of key variables; and (3) subsample analyses based on firm characteristics such as industry classification, firm size, and ownership structure.

5. Results

5.1 Descriptive Statistics

Table 3 presents the descriptive statistics for all variables included in the analysis. The sample consists of 3,320 firm-year observations from 523 Thai listed companies over the period 2018-2024. The mean ESG score is 45.32, with a standard deviation of 18.76, indicating considerable variation in ESG performance among Thai listed companies. Digital finance (DF) has a mean value of 0.58, suggesting moderate adoption of digital financial services among sample firms. Financing constraints (FC), measured by the SA index, show a mean of -3.42, while green

innovation (GI) has a mean of 2.15 green patents per firm. Approximately 38% of the sample firms are classified as family-owned businesses, consistent with the family-dominated nature of the Thai capital market (PwC, 2023).

Table 3: Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min	Max
ESG	3,320	45.32	18.76	5.20	92.45
DF	3,320	0.58	0.24	0.12	0.95
FC	3,320	-3.42	1.28	-6.85	-0.92
GI	3,320	2.15	3.42	0.00	28.00
Family Own	3,320	0.38	0.49	0.00	1.00
LEV	3,320	0.45	0.22	0.02	1.85
SIZE	3,320	15.82	1.65	11.24	21.35
AGE	3,320	18.45	12.32	1.00	48.00
PBV	3,320	2.35	2.18	0.15	18.65
CFO	3,320	0.08	0.12	-0.45	0.52
BIG4	3,320	0.62	0.49	0.00	1.00

Note: Variable definitions are provided in Table 2.

5.2 Correlation Analysis

Table 4 presents the Pearson correlation matrix for all variables. The results show a significant positive correlation between digital finance (DF) and ESG performance ($r = 0.342$, $p < 0.01$), providing preliminary support for H1. Digital finance is negatively correlated with financing constraints ($r = -0.285$, $p < 0.01$) and positively correlated with green innovation ($r = 0.298$, $p < 0.01$), suggesting potential mediating relationships. The correlation coefficients among independent variables are all below 0.70, indicating that multicollinearity is not a serious concern in this study. Variance inflation factors (VIF) were also calculated, with all values below 3.0, further confirming the absence of multicollinearity issues.

Table 4: Pearson Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) ESG	1.000							
(2) DF	0.342***	1.000						
(3) FC	-0.215***	-0.285***	1.000					
(4) GI	0.387***	0.298***	-0.142***	1.000				
(5) Family Own	0.085**	0.124***	-0.068*	0.042	1.000			
(6) LEV	-0.156***	-0.082**	0.345***	-0.098***	-0.052	1.000		
(7) SIZE	0.425***	0.312***	-0.485***	0.356***	0.145***	-0.125***	1.000	
(8) AGE	0.198***	0.085**	-0.215***	0.142***	0.268***	-0.042	0.385***	1.000

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Variable definitions are provided in Table 4

5.3 Regression Results

5.3.1 Direct Effect of Digital Finance on ESG Performance (H1)

Table 5 presents the regression results for the direct effect of digital finance on ESG performance. Column (1) shows the baseline model with control variables only, while Column (2) includes the digital finance variable. The coefficient of DF is positive and statistically significant ($\beta = 12.458$, $p < 0.01$), indicating that a one-unit increase in digital finance index is associated with a 12.458-point increase in ESG score, after controlling for firm-specific characteristics. This result supports Hypothesis 1, confirming that digital finance development has a significant positive effect on corporate ESG performance in Thai listed companies. The adjusted R^2 increases from 0.285 in the baseline model to 0.342 when DF is included, suggesting that digital finance explains an additional 5.7% of the variation in ESG performance.

Table 5: Regression Results - Direct Effect (H1)

Variable	(1) Baseline	(2) With DF
DF	—	12.458***
		(2.845)
LEV	-5.234***	-4.856***
	(1.245)	(1.198)
SIZE	4.125***	3.542***
	(0.456)	(0.425)
AGE	0.185***	0.162***
	(0.042)	(0.038)
Controls	Yes	Yes
Year FE	Yes	Yes
Industry FE	Yes	Yes
N	3,320	3,320
Adj. R^2	0.285	0.342
F-statistic	45.23***	52.18***

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Standard errors in parentheses. Dependent variable is ESG score.

5.3.2 Mediation Effects (H2 and H3)

Table 6 presents the results of the mediation analysis following the Baron and Kenny (1986) approach. Panel A shows the mediation effect of financing constraints. In Step 1, digital finance significantly reduces financing constraints ($\beta = -0.482$, $p < 0.01$). In Step 2, when both DF and FC are included in the model, the coefficient of DF decreases from 12.458 to 9.856, while FC shows a significant negative effect on ESG ($\beta = -2.145$, $p < 0.01$). The Sobel test confirms the significance of the indirect effect ($z = 4.52$, $p < 0.01$), supporting H2 that financing constraints partially mediate the DF-ESG relationship. Panel B presents the mediation effect of green innovation. Step 1 shows that digital finance significantly promotes green innovation ($\beta = 2.856$, $p < 0.01$). In Step 2, when both DF and GI are included, the coefficient of DF decreases from 12.458 to 8.245, while GI shows a significant positive effect on ESG ($\beta = 1.485$, $p < 0.01$). The Sobel test confirms the significance

of this indirect effect ($z = 5.18$, $p < 0.01$), supporting H3 that green innovation partially mediates the DF-ESG relationship. The proportion of the total effect mediated by financing constraints and green innovation is approximately 20.9% and 33.8%, respectively.

Table 6: Mediation Analysis Results (H2 and H3)

	Step 1: FC	**Step 2: ESG**	**Sobel Test**
Panel A: FC Mediation (H2)			
DF	-0.482***	9.856***	z = 4.52***
FC	—	-2.145***	
Indirect Effect		2.602 (20.9%)	
Panel B: GI Mediation (H3)	**Step 1: GI**	**Step 2: ESG**	**Sobel Test**
DF	2.856***	8.245***	z = 5.18***
GI	—	1.485***	
Indirect Effect		4.213 (33.8%)	

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. All models include control variables and fixed effects. Percentages indicate proportion of total effect mediated.

5.3.3 Moderation Effect of Family Ownership (H4)

Table 7 presents the regression results for the moderation effect of family ownership on the digital finance-ESG relationship. Column (1) shows the main effects model, while Column (2) includes the interaction term (DF × Family Own). The coefficient of the interaction term is positive and statistically significant ($\beta = 4.285$, $p < 0.01$), indicating that family ownership strengthens the positive effect of digital finance on ESG performance. This result supports Hypothesis 4, suggesting that family-owned firms benefit more from adoption of digital finance in terms of ESG performance improvement. The finding is consistent with the argument that family owners have longer investment horizons and stronger reputational concerns, which enhance the sustainability benefits of digital finance.

Table 7: Moderation Analysis Results (H4)

Variable	**(1) Main Effects**	**(2) With Interaction**
DF	12.458***	10.125***
	(2.845)	(2.654)
Family Own	2.156**	-0.542
	(0.985)	(1.245)
DF × Family Own	—	4.285***
		(1.456)
Controls	Yes	Yes
Year FE	Yes	Yes
Industry FE	Yes	Yes
N	3,320	3,320
Adj. R^2	0.345	0.358

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Standard errors in parentheses. Dependent variable is ESG score.

5.4 Robustness Tests

Several robustness tests were conducted to validate the main findings. First, we employed instrumental variable (IV) estimation using the regional digital infrastructure development as an instrument for digital finance. The IV results confirm the positive effect of digital finance on ESG performance ($\beta = 11.856$, $p < 0.01$), with the Durbin-Wu-Hausman test suggesting no serious endogeneity concern ($p = 0.245$). Second, we used alternative measures of ESG performance, including individual E, S, and G pillar scores. The results show that digital finance positively affects all three pillars, with the strongest effect on the environmental dimension ($\beta = 15.234$, $p < 0.01$). Third, we conducted subsample analyses based on firm size and industry classification. The positive effect of digital finance on ESG is stronger for larger firms and firms in high-technology industries. Finally, we performed placebo tests using lagged ESG scores as dependent variables, finding no significant spurious relationships.

5.5 Summary of Hypothesis Testing

Table 8 summarizes the results of hypothesis testing. All four hypotheses are supported by empirical evidence. Digital finance has a significant positive direct effect on ESG performance (H1 supported). Both financing constraints (H2) and green innovation (H3) partially mediate the digital finance-ESG relationship. Family ownership positively moderates this relationship (H4), with family-owned firms benefiting more from digital finance in terms of ESG improvement.

Table 8: Summary of Hypothesis Testing

Hypothesis	Description	Coefficient	Result
H1	DF → ESG (Direct Effect)	12.458***	Supported
H2	DF → FC → ESG (Mediation)	z = 4.52***	Supported
H3	DF → GI → ESG (Mediation)	z = 5.18***	Supported
H4	Family Ownership moderates DF → ESG	4.285***	Supported

Note: *** $p < 0.01$. DF = Digital Finance; ESG = ESG Performance; FC = Financing Constraints; GI = Green Innovation.

6. Discussion

6.1 Discussion of Findings

This study investigates the relationship between digital finance and corporate ESG performance in Thai listed companies, with particular attention to the mediating roles of financing constraints and green innovation, as well as the moderating role of family ownership. The empirical findings provide robust support for all four hypotheses, offering new insights into the mechanisms through which digital finance influences corporate sustainability outcomes in emerging markets. The finding that digital finance positively affects ESG performance (H1) is consistent with prior research documenting the transformative impact of digital technologies on corporate behavior

[3,4]. This result extends the literature by demonstrating that the benefits of digital finance extend beyond financial performance to encompass broader sustainability outcomes. In the Thai context, where the Stock Exchange of Thailand has actively promoted ESG disclosure since 2015, digital finance appears to facilitate corporate engagement with sustainability initiatives by reducing information asymmetries and transaction costs associated with ESG investments. The mediation analysis reveals that financing constraints and green innovation serve as important transmission channels linking digital finance to ESG performance. The finding that digital finance reduces financing constraints, which in turn improves ESG performance (H2), aligns with the resource-based view and agency theory perspectives. Digital financial services expand access to capital and reduce the cost of financing, enabling firms to allocate more resources to sustainability investments that might otherwise be foregone due to capital constraints [5]. This finding is particularly relevant for Thai firms, many of which face significant financing barriers that impede long-term sustainability investments.

The mediation effect through green innovation (H3) highlights the role of digital finance in promoting environmentally sustainable business practices. Digital financial platforms facilitate access to green financing instruments, support R&D investments in clean technologies, and enable knowledge transfer and collaboration across industries [7]. The stronger mediation effect of green innovation compared to financing constraints (33.8% vs. 20.9%) suggests that the innovation channel is particularly important in the Thai context, where firms are increasingly recognizing the strategic value of environmental innovation for long-term competitiveness. The positive moderating effect of family ownership (H4) provides novel insights into the heterogeneous effects of digital finance across ownership structures. Family-owned firms, which dominate the Thai capital market [9], appear to derive greater sustainability benefits from digital finance adoption. This finding can be explained by the longer investment horizons, stronger reputational concerns, and greater stakeholder orientation typically associated with family ownership [24]. Family owners, with their concentrated equity stakes and generational perspective, may be more inclined to leverage digital finance for sustainability initiatives that enhance long-term firm value and family legacy.

6.2 Theoretical Contributions

This study makes several important theoretical contributions to the literature on digital finance and corporate sustainability. *First*, it extends the growing body of research on digital finance by examining its impact on ESG performance, a dimension that has received limited attention in prior studies. While existing research has primarily focused on the financial performance implications of digital finance [11,12], this study demonstrates that digital finance also influences non-financial outcomes related to environmental, social, and governance performance. This contribution responds to calls for a more comprehensive understanding of the broader

implications of financial digitalization for corporate behavior and societal outcomes. *Second,* this study advances our theoretical understanding of the mechanisms linking digital finance to sustainability outcomes. By identifying financing constraints and green innovation as mediating factors, the study provides a more nuanced explanation of how digital finance influences ESG performance. The integration of stakeholder theory, agency theory, signaling theory, and the resource-based view offers a comprehensive theoretical framework that captures the multifaceted nature of the digital finance-ESG relationship. This framework can guide future research in examining similar relationships in other contexts. *Third,* the study contributes to the literature on family business and corporate sustainability by demonstrating the moderating role of family ownership. The finding that family-owned firms benefit more from digital finance in terms of ESG improvement adds to our understanding of how ownership structure shapes the sustainability implications of technological change. This contribution is particularly valuable given the prevalence of family businesses in emerging markets and the growing interest in understanding their sustainability behavior.

Fourth, the study addresses the geographic bias in existing research by providing empirical evidence from Thailand, an important emerging market that has been underrepresented in the digital finance literature. By examining the digital finance-ESG relationship in the Thai context, this study enhances the external validity of prior findings and highlights context-specific factors that shape this relationship in ASEAN economies.

6.3 Practical Implications

The findings of this study have important practical implications for multiple stakeholders in Thailand and other emerging markets. For policymakers and regulators, the study provides evidence-based recommendations for leveraging digital finance to promote corporate sustainability and achieve sustainable development goals. Given the positive relationship between digital finance and ESG performance, policymakers should consider initiatives that promote digital financial inclusion, reduce barriers to digital finance adoption, and encourage the development of green financial products and services. The Stock Exchange of Thailand and the Bank of Thailand could collaborate to create regulatory frameworks that incentivize firms to integrate digital finance with sustainability strategies. For corporate managers, the study offers insights into how digital financial technologies can be strategically utilized to improve ESG performance. The findings suggest that investments in digital finance capabilities can generate sustainability benefits by reducing financing constraints and promoting green innovation. Managers should consider integrating digital finance strategies with their sustainability agendas, leveraging digital platforms to access green financing, enhance stakeholder engagement, and support environmental innovation initiatives. The stronger effect observed for family-owned

firms suggests that these companies are particularly well-positioned to capitalize on the sustainability benefits of digital finance.

For investors and financial analysts, the study enhances understanding of the relationship between digital finance capabilities and corporate sustainability. The positive association between digital finance and ESG performance suggests that digital finance adoption can serve as a signal of a firm's commitment to sustainability and long-term value creation. Investors seeking to incorporate ESG factors into their investment decisions may consider digital finance capabilities as an additional criterion for evaluating corporate sustainability. The finding that family-owned firms derive greater sustainability benefits from digital finance may also inform investment strategies in family-dominated markets like Thailand.

For financial technology providers and digital platform operators, the study highlights the potential for digital finance to contribute to sustainability goals. Fintech companies can develop specialized products and services that help firms improve their ESG performance, such as green loan platforms, sustainability-linked financing tools, and ESG data analytics services. By aligning their business models with sustainability objectives, fintech providers can capture new market opportunities while contributing to broader societal goals.

6.4 Limitations and Future Research

While this study provides valuable insights into the relationship between digital finance and ESG performance, several limitations should be acknowledged, which also point to opportunities for future research. *First,* the study focuses on Thai listed companies, which may limit the generalizability of findings to other countries and contexts. Future research could extend this investigation to other ASEAN countries or compare the digital finance-ESG relationship across different institutional and cultural contexts. Cross-country studies would help identify the boundary conditions under which digital finance most effectively promotes corporate sustainability. *Second,* the measurement of digital finance relies on aggregate indices that may not capture the full complexity of firms' digital finance adoption. Future research could employ more granular measures of digital finance, such as specific digital financial technologies (mobile payments, blockchain, AI-powered lending) or firm-level digital finance adoption indicators. Qualitative research methods, including case studies and interviews, could provide deeper insights into how firms integrate digital finance with their sustainability strategies. *Third,* while the study examines financing constraints and green innovation as mediating mechanisms, other potential mediators warrant investigation. Future research could explore additional channels, such as corporate governance improvements, stakeholder engagement, supply chain transparency, and risk management capabilities. A more comprehensive understanding of the multiple pathways linking digital finance to ESG performance would enhance both theory and practice. *Fourth,* the study period (2018-2024) captures a dynamic period of digital finance

development in Thailand, including the COVID-19 pandemic, which accelerated digital transformation. Future research could examine how the digital finance-ESG relationship evolves over time and whether pandemic-induced changes in digital finance adoption have lasting effects on corporate sustainability. Longitudinal studies with longer time horizons would help establish the long-term sustainability implications of digital finance. *Finally*, future research could examine the individual components of ESG (environmental, social, and governance) to determine whether digital finance has differential effects across these dimensions. The robustness tests in this study suggest that digital finance may have the strongest effect on environmental performance, but more detailed investigation is needed to understand the mechanisms underlying these differential effects.

7. Conclusion

This study examines the impact of digital finance on corporate ESG performance in Thai listed companies, investigating the mediating roles of financing constraints and green innovation, as well as the moderating role of family ownership. Using panel data from 523 companies over the period 2018-2024 (3,320 firm-year observations), the study finds robust evidence that digital finance positively affects ESG performance. This relationship is partially mediated by the reduction of financing constraints and the promotion of green innovation, with family ownership strengthening the positive effect of digital finance on ESG performance.

The findings contribute to our theoretical understanding of the mechanisms linking digital finance to corporate sustainability and have important implications for policymakers, corporate managers, investors, and financial technology providers in Thailand and other emerging markets. As digital finance continues to transform the financial landscape, understanding its sustainability implications becomes increasingly critical for achieving sustainable development goals.

In an era of rapid technological change and growing sustainability concerns, this study demonstrates that digital finance can serve as an enabler of corporate sustainability, particularly when combined with supportive ownership structures and innovation-oriented strategies. By reducing financing barriers and promoting green innovation, digital finance offers a promising pathway for emerging market firms to enhance their ESG performance and contribute to sustainable development. The findings underscore the importance of integrating digital finance development with sustainability objectives in policy and corporate strategy, particularly in family-dominated markets like Thailand where the sustainability benefits of digital finance appear to be most pronounced.

Conflicts of Interest: The authors declare that there are no conflicts of interest regarding the publication of this paper.

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